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Relational data model for management of selected items in the Army logistics operation.

Yoon, Chang-sµop; Sup, Yoon Chang

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RELATIONAL DATA MODEL FOR MANAGEMENT OF SELECTED ITEMS IN THE ARMY LOGISTICS OPERATION

Yoon Chang Sup

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

Relational Data Model
For Management Of Selected Items
In The Army Logistics Operation

by

Yoon Chang Sup

December 1979

Thesis Advisor: N. Schneidewind

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The logical data base was derived using the entity-relationship model and is intended for use within a relational data base system. This model was tested using INGRES, a relational data base management system (DBMS) running on the UNIX operating system.

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by

Yoon, Chang Sup
Lieutenant Colonel, The Republic Of Korea Army
B.S., The Korean Military Academy, 1964

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requirements of the degree of

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TABLE OF CONTENTS

I. INTRODUCTION

The primary mission of logistics is to insure the operation of weapon systems on the battlefield. Logistics encompasses a broad spectrum of functions and responsibilities which are required in order that the ultimate objective can be achieved.

Generally speaking, the Department of Army Headquarters level establishes priorities, allocates resources and manages selected items (mission-essential) for supply and maintenance operations.

Information which is used for these selected items, leads us to a design of a data model for planning, operating, and controlling the logistics system. The data model should contain information about:

-- Resources available.

-- Their location.

-- Their state of combat readiness.

A logical data base is a conceptual representation of the information content of the data base. Its design is primarily concerned with the conceptual structure of the data which is necessary in order to meet the requirements of the user community. In this thesis, the general capabilities of the relational data base management system will be fully applied throughout the design process.

Appendix A contains a brief description of the entity-relationship model in which a diagrammatic technique is utilized.

II. ARMY LOGISTICS STRUCTURE AND ADP SUPPORT

A. LOGISTICS STRUCTURE

Just as the army itself is a composite defense system, the system which keeps it supplied and operational is a composite of material, personnel and facilities, processes and organizations, and different levels and varieties of activities, all in motion together and all merging in the common and basic objective of meeting the requirements of the forces.

Logistics is essentially the movement and support of forces in the field and includes the following principal functions: supply, maintenance, transportation, service and facilities. The supply function of logistics includes: the procurement, distribution, maintenance while in storage, and salvage of supplies including the determination of quantities of supplies. Supplies are the commodities necessary to equip, maintain, and operate a military force. Basically, the mission of logistics can be described as: to develop and maintain maximum combat power through the support of weapon systems.

There are three major echelons of logistics support which are determined by types of work done at each echelon. /FM 13/

* Wholesale Echelon
* Intermediate Echelon
* Direct Support/User Echelon

Wholesale Echelon includes depots, maintenance points, plants and factories associated with special army activities retained under Army Headquarters.

Intermediate Echelon provides the major interface between the wholesale and direct support/user echelon. It includes units in the field which provide general support supply, maintenance, transportation, facilities and services.

Direct Support/User Echelon includes field units which provide direct support supply, maintenance, transportation and services. Users include the combat, combat support, and combat service support units utilizing the services and equipment which are the responsibilities of the logisticians.

Logistics responsibilities are different for different levels of the hierarchy. The Deputy Chief of Staff for Logistics (DCSLOG) is the principal logistics advisor to a commander (i.e., Chief of Staff). He has general staff responsibility for developing and supervising army logistics organizations and systems including plans, policies, programs, doctrines, procedures and standards. The responsibilities of other staff officers having significant impact on logistics in a higher level of commands are:

-- Comptroller
  * Cost analysis and fund control.

-- Chief of Staff for Operations and Plans
  * Development of material and force requirements.
  * Establishing priorities for requirements and user test and evaluation.

-- Chief representatives of technical service
  * Communication/Electronics
  * Quartermaster
  * Engineer
  * Ordnance
  * Transportation
  * Chemical
  * All representatives assist the principal logistic staff in logistics function relating to the material of the service.

In a multi-corps army structure, army headquarters provides overall management of logistics. This headquarters establishes priorities, assigns logistics missions, and allocates resources.

The army headquarters utilizes a functional component (i.e., Material Management Center in the United States Army) to control and manage selected items which the army commander (or the Chief of Staff) feels are so critical that he must retain control over the material.

Further down, at the division level, including corps, have the same functional components as the army level and manage logistics operations by monitoring the operational readiness of weapon systems.

B. ADP SUPPORT

The ADPC (Automatic Data Processing Center) within the logistics structure provides significant support. In order to effectively command and control any operations, the commander must have adequate visibility.

The use of automatic data processing (ADP) systems has significantly increased the commander's visibility and has had an effect on logistics operations.

The ADPC dedicated to the logistics operations supports its own internal functions such as stock controls within its area of responsibility and a routine report for higher command.

One of the report generation functions which is a concern of this thesis is the Army Unit Equipment Status Reporting System.

This reporting system is designed to provide up-to-date accurate equipment status data for selected items pertaining to each army unit.

These reports provide information needed by the army headquarters to evaluate the development readiness of military elements in terms of their equipment. The reports also indicate shortages or overages of equipment and, when integrated with other reports, allow army headquarters to determine new procurement needs, prepare budgets, redistribute assets and take disposal actions.

The army equipment status reporting system is a command responsibility at all echelons within their respective organizations. All elements are responsible for developing internal procedures for reviewing, editing and verifying the equipment status data reported under this program.

Items to be reported on equipment status reports are listed in an army supply document (i.e., SB700-20). These reports are generated and forwarded by major commands with cutoff dates of middle of the first month in each quarter.

III. PROBLEM DEFINITION

Information is the trigger for subsequent flows of physical material or for follow-up actions in logistics systems.

If demand exceeds supply (on-hand quantity versus the authorized level), it triggers equipment orders and focuses the commander's attention on the critical material.

Information is used for planning, operating, and controlling the overall logistics systems.

These uses provide a convenient framework for discussing the design of a data model for logistics information. As illustrated in Table 1, there are contrasts in the characteristics of information and its use for logistics system planning, operation, and control.

Logistics system planning of any magnitude occurs periodically (generally quarterly-based on army logistics) in most military organizations.

The cost associated with such planning is spent for data collection and processing. Much of the data processing activity associated with planning involves manual preparation of data.

This manual preparation causes delay in the command action when responding to the demands generated by some urgent user.

The Army Equipment Status Reporting System provides the major equipment status (mainly on-hand quantity and the authorized items) of each responsible command for the logistics mission of army headquarters.

TABLE I /Heskett 9/

Characteristics Of Information Use In Each Management Activity	PLANNING	OPERATION	CONTROL
Degree Of Aggregation Of Information	HIGH	LOW	MODERATE
Importance Of Information External To The Current Logistics System	HIGH	LOW	MODERATE
Currency Of Information Use	LOW	HIGH	MODERATE
Frequency Of Information Use	LOW	HIGH	MODERATE
Relative Cost In Each Management Activity Of			
Data Collection	60	25	30
Data Communication	5	40	15
Data Processing	30	30	35
Data Distribution	5	5	20
	100	100	100

The Nature Of Information, Its Use, And Its Costs In Various Logistics Management Activities.

Each individual report generated by the system reflects the unit's status by items, that gives the logistic operator in the army headquarters an absolute value of the specific unit considered in logistics action based on the data.

An absolute value refers to the indicated quotient (i.e., percentage) between the authorized and the on-hand quantity of a given line item which is authorized in a unit. Unit "A" is said to be relatively higher than unit "B" if the absolute value of unit "A" is higher than that of unit "B" and both units belong to same basic authorization document. This comparative figure is called a relative value, for example, number of divisions in a main battle area compound with the number of divisions in a rear area.

Most of the logistics action required in army headquarters demands a relative value between the units considered and the rest of the units which have the same type of equipment on-hand or authorized in an appropriate document (T/E or T/A).

The reconstructing of data (information) from absolute value to relative value has been done mostly by manual preparation.

The Principal Logistics Advisor (DCSLOG) and other staff officers share the data base. However, depending on the currency of the data related to the commander's needs, each department concerned with the request collects the data through the technical chain of communication of each service without coordination between them.

These collections of data cause duplication of time and effort, and serious inconsistencies between departments when the data and recommendation based on the data come to the commanders for use in decision making.

Because of the time duration, some departments frequently collect and store duplicate information. One department is not aware of the data which another one possesses; another department can easily obtain information which several other departments need but have great difficulty in acquiring.

This problem is due to the time duration of the data collection, which is quarterly in the case of the Army Equipment Status Report. There is no further updating between periodic reports.

IV. INFORMATION REQUIREMENT SPECIFICATION AND ANALYSIS

The entire data base design process has been described as consisting of the following phases [Kahn 77].

Phase 1 - Information requirements specification and analysis.

Phase 2 - Logical data base design.

Phase 3 - Evaluation of logical data base design.

Phase 4 - Physical data base design.

Phase 5 - Evaluation of physical data base design.

Phase 6 - Data base construction and initialization.

Phase 7 - Performance evaluation.

Logical data base design deals with how to conceptually structure the data to meet the needs of the user community and to efficiently fit it within the framework of physical data base design.

With a data base management system, the user is relieved of much of the task of physical data base design. The user or implementor must now be much more concerned with logical data base design in order to make good use of the capabilities of the data base management system.

The data base being designed should allow the Army Chief Of Staff, logisticians, and other staff officers in DOA Headquarters to more quickly and accurately know

-- what resources are available;

-- where they are located; and

-- their state of combat readiness.

Meeting this information requirement demands visibility over material availability and material committed by DOA Headquarters. With material availability, DOA Headquarters can make decisions about subsequent flows of material to meet the material request.

With material committed, DOA Headquarters can refer to status reports in order to make sound decisions about keeping units in a state of material readiness.

For example, in case of a request for issuance of a specific end item by a unit, a logistician at DOA should know the stock level of the item in the corresponding depot. He also simultaneously needs information about quantity on-hand status of the item at the same level as the requesting unit, including the GS level, if necessary.

The data base design is primarily concerned with the following information about the selected end items.

-- Quantity authorized and on-hand of the selected end item by each unit.

-- Which units and how many units possess a specific item.

-- Stock level of operational stock, including war reserve and operational project stock in the army-wide depot and of operational stock in GS level (intermediate level of logistics structure).

-- Maintenance float including Operational Readiness Float in GS level and Repair Cycle Float in the army-wide depots.

-- Contractor Repair Status and its association with the army-wide depot.

-- Authorization documentation supporting a specific unit.

-- Association between line item number and National Stock Number and detailed description of selected items including price.

-- Material acquisition project status associated with line item, supplier, and quantity.

-- Material utilization project status associated with line item and quantity available.

Before formulating the data usage matrix, the military (army) documentation and relevant informations about the information requirements previously stated will be discussed in order to provide a sound and reasonable design.

The documentation and relevant information are presented in Sections A1 through A7.

A. DOCUMENTATION AND RELEVANT INFORMATION

1. Material Authorization And Requirement Documentations

/ FM 14 /

The Army Authorization Document System (TAADS) is an Army-wide system designed to centralize the control of personnel and equipment required by and authorized to army units.

Under this system, each unit's requirements and authorizations for personnel and equipments are specified by a basic authorization document.

For the thesis purpose, the equipment requirement and the authorization parts of the documentations will be reviewed and considered.

There are three basic documentations:

-- Table of Organization and Equipment (TOE) (Modified TOE)

-- Table of Distribution and Allowances (TDA)

-- Common Tables of Allowances (CTA)

CTA lists items which are common to all types of units. The CTA's are used along with the TDA's and TOE's (MTOE's) to determine total material authorizations for TDA and TOE units.

CTA documentation will not be considered as an entity in this data base because the authorized quantity of each individual line item in appropriate CTA documentation will be calculated based on corresponding figures in a respective MTOE/TDA and be reflected as an authorized quantity on the MTOE/TDA.

The primary responsible department for plan preparation, publication and updating of these documentations is the Deputy Chief of Staff for Operation and Plan (DCSOP) in the Department of Army Headquarters.

a. Table Of Organization And Equipment (TOE) And Modification Tables Of Organization And Equipment (MTOE)

A TOE is published for every type of unit in the army having a field mission. Some TOE prescribe the organizational structure and the personnel and equipment requirements for various units.

The TOE numbering system consists of one or two digit basic number and one, two, or three digit sub-number with a letter suffix (i.e., TOE 6-358H) (US AR 310-2). A complete list of basic numbers is given below:

1 - Aviation

2 - Chemical

5 - Engineer

6 - Field Artillery

7 - Infantry

8 - Medical

9 - Ordnance

10 - Quartermaster

11 - Signal

29 - Composite Units And Activities

Contents of Section III in each TOE contains line item number (LIN), description, authorized quantity of equipment in accordance with the strength level and other informations for each sub-element of the unit.

However, Recapitulations of Equipment are given just after the list if equipment in Section III. All items are listed here in line item number sequence.

The recap shows total quantities of each LIN item required for the units. Data items shown in TOE and concerned with the thesis purpose are:

-- LIN

-- Description (Nomenclature)

-- Quantity authorized in the strength level

b. Modification Tables Of Organization And Equipment (MTOE)

The MTOE is used to modify a basic published TOE to meet the particular needs of a specific unit or group of units (i.e., a division or several divisions of the same type such as infantry).

A detailed MTOE becomes the official authorization document to support the unit's material readiness in terms of material requirements.

The format of MTOE is the same as that of the basic TOE it modifies except for the data items shown below simply replacing the authorized quantities of each level strength in TOE.

-- Required Quantity

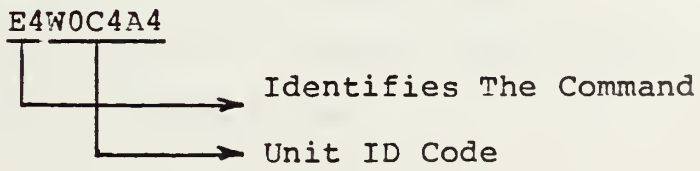
-- Authorized Quantity

MTOE numbers are the same as the TOE they modify except for the addition of a four-position suffix describing the command under which the unit is operating and numbers of modification. For example: MTOE-7-15HE701

c. Tables Of Distribution And Allowances (TDA)

The TDA is the official authorization document for the organization of a non-TOE unit. The unit uses the TDA as a guide for the assignment of personnel and distribution of equipment within the unit.

The TDA numbering system includes TDA number, the command and control number (CC-NUM) and the effective date (EDATE). The TDA number consists of eight characters (for example: E4W0C4A4) constructed as below. TDA number does not have basic number as MTOE has from the corresponding TOE modified.



The equipment allowance part of the TDA reflects requirements and authorization for all non-expendable equipment which has been assigned standard line item number (LIN).

The required and authorized quantity of each line item are described in TDA as in MTOE.

2. Line Items (Mostly Class VII)

Supply bulletins (SB's) are published to provide various types of information on items of supply.

SB700-20 is one of the most important reference publications in the supply organization. It provides a list of Army-adopted items and other selected informations.

Data items described in the documentation are:

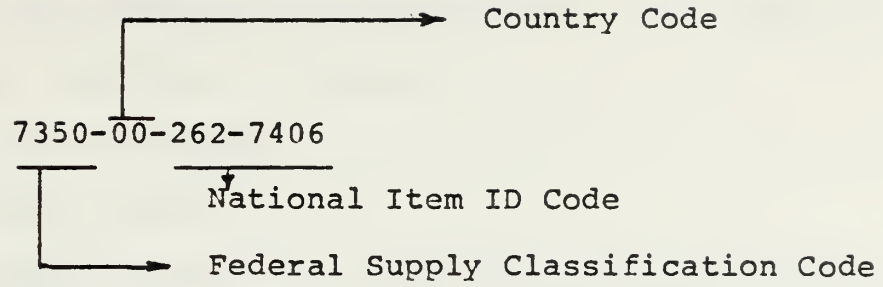
-- Reportable item control code (RICC)
-- National stock number (NSN)
-- Line item number
-- Association between LIN and NSN
-- Item nomenclature
-- Unit price
-- Other supply data required for preparing supply records

This documentation provides a quick way to identify items in the supply system. A cross-reference of NSN to LIN is also available. Many of the supply data described above are published and distributed in mocrofiche form.

The data items used for describing line items are:

a. National Stock Number (NSN)

The NSN has 13 numbers which are divided into four (4) groups as shown below:



Country code can be eliminated without losing unique identification.

b. Line Item Number (LIN)

The LIN represents one or group of NSN items which can be substituted for each other within the same LIN. As stated earlier in the material authorization and requirement documentation (TOE, MTOE, TDA) these documentations contain only line item numbers (LIN) to describe line items required for accomplishment of unit mission. By referring to appropriate LIN, a group of NSN items can be found and one of NSN items can be filled for unit requirement.

For example, 1/4 Ton Utility Truck:

LIN is X60833

NSN's are:

2320-00-177-9258 TRK UTIL 1/4T M151A2

2320-00-542-4783 TRK UTIL 1/4T M151

2320-00-763-1092 TRK UTIL 1/4T M151A1

2320-00-835-8318 TRK UTIL 1/4T M38

2320-00-835-8319 TRK UTIL 1/4T M38A1

It is very obvious that different models have different prices and each individual model has a distinct NSN.

c. Nomenclature (Description)

The nomenclature describes the line items as shown above: TRK UTIL 1/4T M151A2.

d. Unit Of Issue

e. Unit Price

f. Other Information Such As Logistics Control Code (LCC), Equipment Report Criteria (ERC, same as RICC) And Type Class.

The primary responsible department for plan, preparation, publication and updating of these documentations is the Deputy Chief of Staff for Logistics (DCSLOG) in the Department of Army Headquarters.

3. Units (Commands)

The level of command such as division in terms of data item in the data base, will be determined by degree of interest in which the Department of Army Headquarters will consider as a basic unit in planning, operation and controlling of logistics management.

a. Priority

Since our military forces are designed for combat, an organization that is operating in combat is given a higher priority on its requests for equipment than an organization being kept in a state of readiness or one that is being trained.

Associated with the priority is the Uniform Material Movement and Issue Priority System (UMMIPS).

UMMIPS assigns to each organization a force/activity designator (FAD) in accordance with its military mission. Simultaneously, UMMIPS provides a way to indicate the urgency of the need for each item requested.

The requesting organization must consider the urgency of need for each time requested and select the right designator for each request of line item.

This Urgency Of Need Designator (UND) will not be included in the data base.

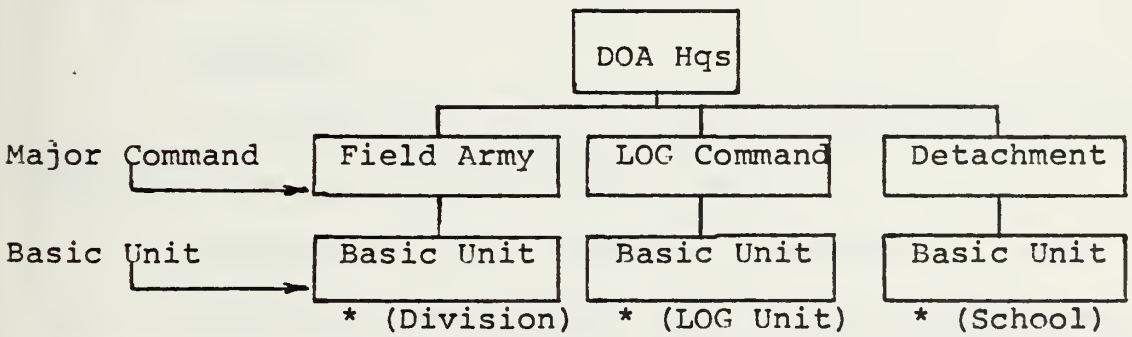
The external request documentation will support judgmental decision process of the logistics operator in DOA level.

b. Identification

Each organization is identified by its unit identification code (UIC), or by unit number consisting of a four (4) digit-position number for its distinct identification.

c. Major Command

Basic unit regarding the data base belongs to one of the major commands under which basic unit is operating. These major commands refer to the next highest command level below the DOA Headquarters.



*(Example)

The total force structure of the army is the responsibility of DCSOP in DOA Headquarters. A unit is identified by it's unit identification code (UIC).

The information included in the Army Equipment Status Reporting for a specific unit is:

-- Authorized Line Item Number (LIN)

-- On-hand Line Item Number (LIN)

-- National Stock Number NSN)

-- On-hand Quantity

-- Short NSN Nomenclature

Authorized LIN and NSN nomenclature are provided in the corresponding Authorization Table such as MTOE and TDA.

NSN corresponding to a given LIN is provided in appropriate supply documentation as mentioned in Line Item.

The only information needed to describe the status of equipment on-hand for a specific unit, but are not provided in any documentation are:

-- NSN (a specific equipment on-hand within the authorized LIN in MTOE/TDA)

-- On-hand Quantity

4. Stockage

The stocks are kept at various levels of the logistics structure such as unit DS, GS, and depot.

Combat units of a division normally draw their supplies (excluding ammunition) from direct support command which in turn maintains stocks (authorized stockage lists) of items most essential to immediate and continued combat operations.

General support units in Field army level maintain back-up stocks for those direct support units they support and maintain additional items not stocked by the direct Support Unit.

The army level provides the army stockage objective and stocks of war reserve and operational project stocks.

The level of logistics structure for stock maintained in the data base will be determined up to army level from next lower level which is GS in a Field Army, in order to provide an adequate visibility over the stock status.

Stock is expressed in terms of level of supply which is used for planning purposes and in the control of supply operations for expressing quantities of supplies or material authorized or directed to be held in anticipation of future demands. Levels may be expressed in days of supply or in quantity per item.

The level of supply consists of operating, safety, replenishment.

Special stocks are maintained in some areas as a war reserve. Operational projects stocks are also kept in various geographical areas to meet the requirement of the operation which the stocks are determined for.

Depots accept supplies from manufacturers and support the entire army according to the missions which are generally determined on the type that is material-category or geographical-area-oriented.

For example, the communication and elctronic depot can only carry communication and electronic material for the entire army inventory items in accordance with the mission performed.

The supply level will be determined by routine operations of each depots.

Selection of line item for war reserve and operational project stock, determination of quantity of each line item, and placement are determined by DOA Headquarters.

5. Contract Repair

Both repairable items scheduled for major repair and overhaul by a maintenance activity (contractor) and repairable items (unserviceable - economically repairable) not scheduled for repair or overhaul will be considered.

Scheduled movement of repairable items from local storage activities to contractor maintenance activities will be as prescribed by the installation commander, based on an authorized repair schedule of DOA Headquarters.

The items repaired by the contractor maintenance and returned to depot will become stocks for further army logistics operations.

The storage activity will furnish the contractor's repair facility with shipping instructions. Normally, these instructions will contain:

-- Contract identification

-- Item stock number and nomenclature

-- Quantity

-- Identification of storage activity shipped from (And returned to)

-- Fund code

-- Information to the contractor that when items received for repair are uneconomically repairable, such condition will be reported immediately to the corresponding storage activity.

-- Due-in.

Upon receipt of the material from contractor's repair facility to the storage facility, the DOA Headquarters will process and receipt due-in for storage as stocks.

6. Project

The projects considered in the data base of logistics operations can be classified into two types:

-- Material Acquisition.

-- Material Utilization.

Either one of these will contain:

-- Project ID.

-- Project description.

-- Responsible department.

-- NSN procured or utilized.

By the nature of the project, some data items describing the project can be different. The information as data items in the data base will not be considered in detail here.

7. Maintenance Float (US AR 750-1)

End items or components of equipment authorized for stockage at installation or activities for replacement of unservicable items of equipment when immediate repair of the unservicable equipment cannot be accomplished by the support maintenance activity. Maintenance float includes both operational readiness float and repair cycle float.

a. Operational Readiness Float (ORF)

End items or major components of mission-essential maintenance equipment authorized for stockage. Normally these are DS/GS maintenance units which are to replace unservicable equipment.

b. Repair Cycle Float (RCF)

An additional quantity of principal items of mission-essential maintenance equipment, specified by DA stockage at the depot level, to permit withdrawal of equipment from organizations for scheduled overhaul without detracting from the unit's readiness. The float is utilized to cover equipment awaiting overhaul, in the overhaul process, and in-transit to and from depot overhaul.

B. DATA USAGE MATRIX FOR LOGISTICS OPERATION (SUPPLY-SELECTED ITEM)

APPLICATION \ DATA ELEMENTS		LIN	NSN	QTY	UNIT	AUTH. DOC.	OPN LEVEL	SAFETY LEVEL	REPL. LEVEL	DEPOT	GS	CONTRACTOR INFO.	PROJECT INFO.	SUPPLIER INFO.
ARMY EQUIPMENT STATUS REPORTING		*	*	*	*	*								
STOCKAGE STATUS	DEPOTS	*	*				*	*	*	*				
	GS's	*	*				*	*	*		*			
MAINT. FLOAT STATUS	DEPOTS	*	*	*						*				
	GS'S	*	*	*							*			
WAR RESERVE		*	*	*						*				
OPERATIONAL PROJECT STOCK		*	*	*						*			*	
MATERIAL ACQ. STATUS		*	*	*									*	*
UNIT AUTH.		*	*	*	*	*								
END ITEM DISTRIBUTION INFORMATION QUERY		*	*	*	*	*	*	*	*	*	*	*	*	
CONTRACTOR REPAIR STATUS		*	*	*						*		*		

C. DATA DICTIONARY

Data dictionary generally has two objectives but with varying degrees of emphasis:

-- Collection and dissemination of data descriptions which entail the functions of supplying the users of data with descriptions of their data, and providing the DBMS with the information it needs to maintain and retrieve data from the data base.

-- Establishment of standards which considers the need to establish standards for such areas as data naming, usage, and coding conventions.

As an important element of the integrated data base, the data dictionary is the central source of control over data specification.

Along with the discussion of documentation and relevant information concerned with the data base design, data elements have been identified in order to build the data dictionary.

The data dictionary will be specified in terms of name and domain, which specifies format and value range and remarks. /Date 5/ Some value ranges of the domain, such as price and quantity (required, on-hand, and stockage level quantity), cannot be specified at this time. However, the maximum values of the corresponding data elements will be specified as the maximum values of the range when the system is implemented.

TABLE II

DATA DICTIONARY

NAME (ATTRIBUTE)	DOMAIN	REMARKS
LIN-NO	LIN-#	Line Item Number
NSN-NO	NSN-#	National Stock Number
NOMEN	Nomenclature	Description of end item
UNIT-PRICE	Price	Unit price of item
UNIT-ISSUE	UNIT-ISSUE	Unit of issue
RICC	RICC	Reportable Item Control Code
AUTH-DOC	AUTH-DOC	Authorized documentation
UIC	UIC	Unit Identification Code
QTY-REQ	QTY-A	Quantity required in MTOE, TDA
QTY-AUTH	QTY-A	Quantity authorized in MTOE, TDA
QTY-OH	QTY-A	Quantity on-hand by unit
QTY-DEL	QTY-P	Quantity delivered IAW Project
QTY-COMT	QTY-P	Quantity committed IAW Project
DATE-E	DATE	Effective date (TDA, MTOE, Project)
DATE-C	DATE	Date completion (Project)
DATE-RESVD	DATE	Date reserved (War Reserve)
DATE-DUE-IN	DATE	Date-Due-In (Contractor repair)
FAD	FAD	Force Activity Designator in UMMIPS

NAME (ATTRIBUTE)	DOMAIN	REMARKS
MAJ-COMD	MAJ-COMD	Major Command under which a unit is operating (Field Army Level)
OPN-STOCK	STOCK-LEVEL	Operating Stock Level (Quantity)
SAFETY-STOCK	STOCK-LEVEL	Safety Stock Level (Quantity)
REPL-STOCK	STOCK-LEVEL	Replenishment Stock Level (Quantity)
DEPOT-ID	DEPOT-ID	Depot Identification
CONTRACTOR-ID	CONTRACTOR-ID	Contractor Repair Identification
FUND-CODE	FUND-CODE	Fund Code (Contractor Repair)
PROJECT-ID	PROJECT-ID	Project Identification Code
PROJECT-DES	PROJECT-DES	Project Description
DEPT-PROJ	Department	Department of DOA responsible for a project
SUP-ID	SUP-ID	Supplier Identification Code
COUNTRY	COUNTRY	Country involved in material acquisition
SERVICE	SERVICE	Service Corps being supported in depot operation
GS-ID	GS-ID	GS Level Identification Code
ADDRESS	ADDRESS	Address Correspondence (Contractor repairs)
PRICE-PURCH	PRICE	Price purchased in project-acquisition
SER-CH	GS-ID	Supply channel between unit and GS level

NAME (ATTRIBUTE)	DOMAIN	REMARKS
QTY-SHIP	QTY-C	Quantity shipped to Contractor Repair Facilities
QTY-REPAIR	QTY-C	Quantity repaired by Contractor Repair and returned to storage facility (Depot)
LOCATION	LOCATION	Location of Contractor Repair Facility
T-QTY-DEL-SCH	QTY-P	Total quantity scheduled to deliver in a project (Acquisition)
T-QTY-DEL-ARR	QTY-P	Total quantity actually arrived in a project (Acquisition)
DATE-DEL-SCH	DATE	Date of scheduled delivery
DATE-DEL-ARR	DATE	Date actually arrived
QTY-DEL-SCH	QTY-P	Quantity scheduled to deliver in one shipment
QTY-DEL-ARR	QTY-P	Quantity actually arrived in one shipment

TABLE III

DATA DICTIONARY (DOMAIN)

DOMAIN	FORMAT	VALUE RANGE
LIN-#	C6	All alphanumeric
NSN-#	C11	Selected item (all alpha-numeric)
NOMENCLATURE	C20	All alphanumeric
PRICE	FX	Non-zero, MAX (prices)
UNIT-ISSUE	C2	/⁻EA, CS, BX, ..._7
RICC	I1	/⁻0, 1, 2, 3_7
AUTH-DOC	C9	All alphanumeric
UIC	C6	All alphanumeric
QTY-A	IX	0, MAX (quantities) in authorization documentation
QTY-P	IX	0, MAX (quantities) in projects
DATE	I6	YR-MON-DATE (700000, 8X0000)
FAD	I1	/⁻0, 1, 2, 3, 4, 5_7
MAJ-COMD	I1	/⁻1, 2, 3, . . . 9_7
STOCK-LEVEL	IX	0, MAX (OPN, SAFETY, REPL) in stockage level in Depot
DEPOT-ID	C6	All alphanumeric
CONTRACTOR-ID	C6	All alphanumeric (contractor involved Army Repair Facility)
FUND-CODE	CX	All alphanumeric
PROJECT-ID	C9	All alphanumeric Project being planned/ Implemented
PROJECT-DES	C20	All alphanumeric
DEPARTMEN	C9	All alphanumeric (Departments in DOA Hqs)

DOMAIN	FORMAT	VALUE RANGE
SUP-ID	CX	All alphanumeric (suppliers involved in material acquisition)
COUNTRY	C5	In/Out Country Code (alphabetic)
SERVICE	C3	Alphabetic /set of service corps/
GS-ID	C6	All alphanumeric /set of GS level/
ADDRESS	C21	All alphanumeric
LOCATION	CX	City, state indicating contractor
QTY-C	IX	Quantity indicating amount of end item being shipped to and returned from Contractor Repair facility

* IX, FX, CX: Indicate the size of integer, floating point, and characters have not been determined, but are dependent on the actual data to be used.

V. LOGICAL DATA BASE DESIGN

After completion of phase I of the data base design process, the organization's requirements have been identified in terms of a data dictionary which describes the data elements and expresses the association between application function and data elements in the form of a usage matrix. Then begins the difficult task of formulating a logical data base design.

Four steps to logical design have been presented in the reference; Appendix A.

1. Identify the entity sets and the relationship sets of interest.
2. Identify semantic information in the relationship sets such as whether a certain relationship is an 1:n mapping (referred to as "connectivity" in [Kahn 7] and "association" in [Taylor 11].
3. Define the value sets (referred to as domain in [Date 5] and attributes.
4. Organize data into entity relationship relations and identify the primary key.

Along with the logical design steps, a number of objectives have to be considered in constructing the integrated data base. These objectives are: [Wiederhold 8]

1. Construct relations with the greatest degree of semantic clarity.
2. Construct the data base using smallest number of relations.
3. Construct the data base so that it will have the smallest number of tuples.
4. Construct the data base so that the number of data elements stored will be minimal.

5. Construct the data base so that the connections between relations and shared attributes will be minimal.

No doubt Wiederhold does not mean that all objectives must be met concurrently.

There are also several basic considerations in designing a relational data base logically. /Codd 3, Wiederhold 8, Martin 67.

-- Ruling party.

-- Functional dependency.

-- Transitive dependency.

-- Relation.

-- Normalization process.

The details of these concepts will not be discussed here.

Normalization reduces the need for restructuring the collection of entities as new elements are introduced into the system and thus increases the life span of application programs. Normalization reduces the number of tuples.

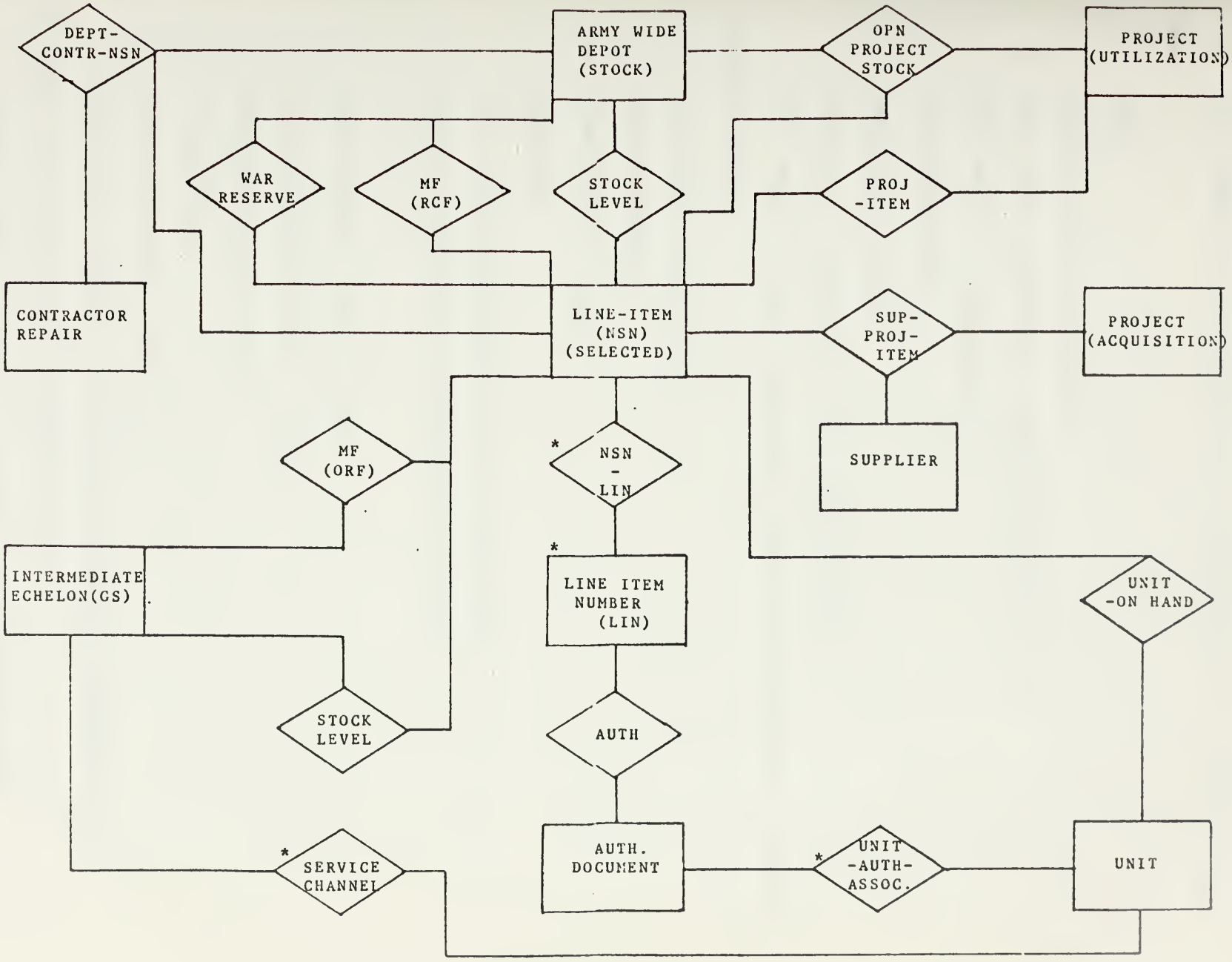
This normalization process can be obtained in step 3 by using the entity-relationship model (see Appendix A).

The entity-relationship model is similar to 3NF relations with clearer semantics and without transformation operations from an arbitrary relation into normalized relations.

However, the process of mapping an attribute to an entity or relationship requires functional dependence and transitive dependence of an attribute on primary attribute(s).

The entities and relationships are expressed in an entity-relationship diagram (Figure 1) which is the output of the first step.

FIG 3: Entity-Relationship Diagram for analysis of information in Logistics(Supply) Operation.



The entities identified are represented by a rectangular box:

-- Unit
-- Authorization documents
-- Line item (selected) including NSN and LIN
-- Intermediate activity (GS)
-- Army wide depot
-- Contractor repair
-- Projects (acquisition and utilization).

The relationships identified are represented by a diamond-shaped symbol:

-- Unit-Auth-association
-- Service-channel
-- NSN-LIN-association
-- MTOE/TDA
-- Stock level including GS and Army depot
-- Maintenance float including ORF and RCF
-- War reserve
-- Operational project stock
-- Project (utilization) - item
-- Supplier-project-item
-- Unit-on-hand
-- Depot-contractor-NSN-assoc.

The total number of relations initially designed are 21 with 9 entities and 14 relationships.

In the steps 2 and 3, connectivity and defining attributes will be processed. The output of steps 2 and 3 is the Appendix B.

The Appendix B shows the following information about entities and relationships:

-- Unique identification of tuples.

-- Attributes.

-- Connectivity in case of relationship.

-- Synonyms where necessary.

-- Cardinality (number of tuples).

-- Interrelationship in case of relationships.

Semantic clarity objectives should be considered in step 3 when attributes are assigned to entity and relationships. The objective of semantic clarity is enhanced when strongly linked attributes are grouped together, and can be obtained with a limited number of relations and interrelation dependencies.

Assigning attributes to entity or relationship demands functional dependency between the ruling party and dependent attributes.

The objective of minimum data elements stored demands non-redundency which may exist among entity and relationship. In order to meet this objective, the separate entity LINE ITEM (NSN) which consists of NOMEN, UNIT-ISSUE, UNIT-PRICE , and RICC will be maintained for the entire data base. Any application and query that needs this information will make a link through the national stock number.

The minimum connection objective can be obtained by using NSN-NO (attribute) and LIN-NO (attribute) when necessary.

Connection between DEPOT-CONTRACTOR-NSN and OPERATIONAL STOCK LEVEL, when the repaired items return to depot stock, can be made through NSN-NO instead of a concatenated key (DEPOT and NSN-NO), because NSN-NO belongs only to a specific depot -- not many depots.

The entity-relationship diagram which was initially designed and the mapping of attributes to entity and relationship is in Appendix B.

The following can be eliminated by combining entity and relationship, which results in reducing relations in order to meet the design objective of smallest number of relations:

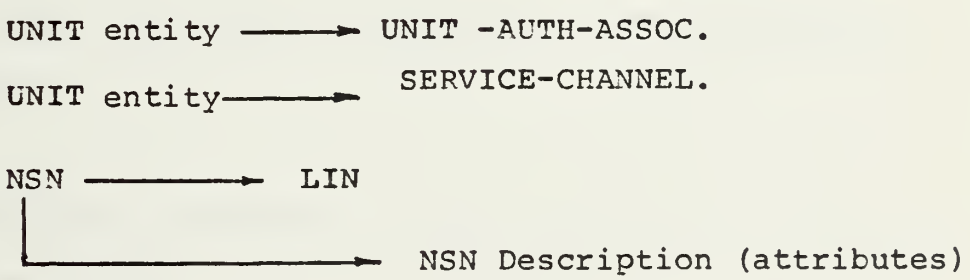
-- UNIT-AUTH-ASSOC. relationship.

-- SERVICE-CHANNEL relationship .

-- LINE ITEM NUMBER (LIN) entity.

-- NSN-LIN-ASSOC. relationship.

The arrow means that if B is functionally dependent on A, an arrow goes from A to B. /Martin 67



The entity and relationship mentioned above do not have any attributes describing them as shown in the Appendix B. If any attributes exist in either of these entities or relationships, the relationship or entity which has attributes will remain as a relation.

By this observation, UNIT-AUTH-ASSOC. and SERVICE-CHANNEL will be attributes of UNIT entity rather than of AUTHORIZATION DOCUMENT and INTERMEDIATE ACTIVITY entity, respectively, which also satisfies the design objective of smallest number of tuples .

LIN entity will be an attribute of NSN-LIN-ASSOC. relation and, further, the relationship can be an attribute of LINE ITEM (NSN) entity, which functionally identifies LIN.

A separate relationship for stock level for GS and for depot should be maintained.

Separate relationships for maintenance float for GS and for depot should exist in the data base. This separation facilitates maintaining the relationship in the data base due to different sources of updating, and also supports two different purposes:

1. Visibility over material committed, and
2. Visibility over material available in view of the DOA level.

The entire data base will consist of the following:

8 Entities

-- Unit

-- Authorization document

-- NSN (selected)

-- Army wide depot

-- Contractor Repair

-- Intermediate activity (GS)

-- Projects (utilization and acquisition)

11 Relationships

-- MTOE/TDA

-- Stock Level (GS)

-- Stock Level (Depot)

-- Maintenance float (ORF, GS)

-- Maintenance float (RCF, Depot)

-- War reserve

-- Project-item (utilization)

-- Operational project stock

-- Supplier-project-item

-- Unit-on-hand

-- Contractor-NSN

Detailed description of entity and relationship relations exist in the data base will be presented at the end of this chapter.

The relational schema of the data base will be specified in the same manner as in /Michaels 12 and Date 57.

The Relational Schema Of The Data Base

Domains

See Data Dictionary (Domain)

Relations

LINE ITEM (NSN-NO, LIN-NO, MOMEN, UNIT-ISSUE, UNIT-PRICE RICC)
KEY: (NSN-NO)

UNIT (UIC, FAD, MAJ-COMD, SER-CH, AUTH-DOC)
KEY: (UIC)

ARMY-WIDE-DEPOT (DEPOT-ID, SERVICE)
KEY: (DEPOT-ID)

AUTHORIZATION (AUTH-DOC, DATE-E)
KEY: (AUTH-DOC)

```
GS-ACTIVITY (GS-ID, MAJ-COMD)
  KEY: (GS-ID)

CONTRACTOR (CONTRACTOR-ID, LOCATION, ADDRESS)
  KEY: (CONTRACTOR-ID)

SUPPLIER (SUP-ID, S-COUNTRY, LOCATION, ADDRESS)
  KEY: (SUP-ID)

PROJECT (PROJECT-ID, DATE-E, DATE-C, PROJECT-DES)
  KEY: (PROJECT-ID)

AUTH (AUTH-DOC, LIN-NO, QTY-REQ, QTY-AUTH)
  KEY: (AUTH-DOC, LIN-NO)

UNIT-ON-HAND (UIC, NSN-NO, QTY-OH)
  KEY: (UIC, NSN-NO)

STOCK-LEVEL-DEPOT (NSN-NO, DEPOT-ID, OPN-STOCK, SAFETY-STOCK,
                   REPL-STOCK)
  KEY: (NSN-NO)

STOCK-LEVEL-GS (GS-ID, NSN-NO, OPN-STOCK, SAFETY-STOCK,
                REPL-STOCK)
  KEY: (GS-ID, NSN-NO)

MF-RCF (NSN-NO, DEPOT-ID, QTY-REQ, QTY-OH)
  KEY: (NSN-NO)

MF-ORF (GS-ID, NSN NO, QTY REQ, QTY OH)
  KEY: (GS-ID, NSN-NO)

WAR-RESERVE (NSN-NO , DEPOT-ID, QTY-REQ, QTY-OH, DATE-RESVD)
  KEY: (NSN-NO)

OPN-PROJ-STOCK (PROJ-ID, NSN-NO, LOCATION, QTY-REQ, QTY-OH)
  KEY (PROJ-ID, NSN-NO, LOCATION)

PROJ-ITEM (PROJ-ID, NSN-NO, QTY-REQ, QTY-COMT)
  KEY: (PROJ-ID, NSN-NO)

CONTR-ACT (CONTRACTOR-ID, NSN-NO, QTY-SHIP, FUND-CODE,
           QTY-REPAIR, DATE-DUE-IN)
  KEY: (CONTRACTOR-ID, NSN-NO)

SUP-PROJ-ITEM (NSN-NO, PROJ-ID, SUP-ID, PRICE-PURCH,
           T-QTY-DEL-SCH, T-QTY-DEL-ARR, DATE-DEL-SCH,
           DATE-DEL-ARR, QTY-DEL-SCH, QTY-DEL-ARR)
  KEY: (NSN-NO, PROJ-ID, SUP-ID)
```

VI. CONCLUSIONS

The complex task of a logical data base design for a relational data base management system can be greatly simplified by use of the entity-relationship model. Entities and relationships between entities, representing information about actual army logistics operations (management of selected end items), have been transformed into the relations of a relational data base management system. The entire data base consists of:

Eight Entities

-- Unit

-- Authorization document

-- NSN (selected)

-- Army wide depot

-- Contractor repair

-- Intermediate activity (GS)

-- Project (utilization and acquisition)

Eleven Relationships

-- Auth (MTOE/TDA)

-- Stock level (GS)

-- Stock level (Depot)

-- Maintenance float (ORF, GS)

-- Maintenance float (RCF, Depot)

-- War reserve

-- Project item

-- Operational project stock

-- Supplier project item

-- Unit on-hand

-- Contractor-(NSN)

The nineteen relations exist in the entire data base in order to support the user requirement of management of selected end item in the DOA Headquarters level.

The individual user's view of the data base can be derived from the stored relations, and queries can refer to the derived relation for further information retrieval.

Throughout the entire data base, the derivable data has not been shown as columns in a relation. However, utility functions, such as the aggregate function in INGRES, can be applied to the stored relation or the derived relation to generate specific data when necessary.

Any subset of the relations in the data base can form a data base in order to meet specific user requirements. The line item relations should be included in the new data base in order to obtain a detailed information about selected end items.

Finally, relational implementations are being developed in universities and research laboratories. It is obvious that a great deal of effort is being devoted to developing, studying, implementing, and analyzing DBMS. These efforts will result in quality software and hardware for all potential users of relational data base management systems.

APPENDIX A

THE ENTITY-RELATIONSHIP MODEL /Chen 1/

This model incorporates some of the important semantic information about the real world. A special diagrammatic methodology is introduced as a tool for data base design.

The Entity-Relationship Model can be used as a basis for unification of different views of data: the Network Model, the Relational Model, and the Entity Set Model.

The Entity-Relationship Model can be used as a framework from which the three data models may be derived.

The author views the Entity-Relationship Model as a generalization of the three models.

1. THE MULTI-LEVEL VIEWS OF DATA

In the Conceptual Data Model /Date 5/, the levels of logical views of data base with which the model is concerned should be identified as follows:

Level 1: Information concerning entities and relationships.

Level 2: Information structure-organization of information in which entities and relationships are represented by data.

Level 3: Access-Path-Independent Data Structure. Pre-determined ordering, indexing, and access path are not involved /Codd 2/.

Level 4: Access-Path-Dependent Data Structures.

The Network Model as currently implemented is considered as an access-path-dependent data structure in Level 4.

The Relational Model is described as an access-path-independent [data independence, Codd 2] data structure. The Entity-Relationship Model is represented by data as in Level 2 and Level 3.

2. TERMS USED IN ENTITY-RELATIONSHIP MODEL

* An entity is a "thing" which can be distinctly identified. A relationship is an association among entities. For example, "STUDENT-COURSE" is a relationship between two entities "STUDENT" and "COURSE".

* Entity and Entity Set. Entities are classified into different entity sets such as EMPLOYEE, PROJECT, and DEPARTMENT. There is a predicate associated with each entity set to test whether an entity belongs to it by properties common to the other entities in the entity set.

* Relationship, Role, and Relationship Set. A relationship Ri, is a mathematical relation among N entities, each taken from an entity set:

$$\{[e_1, e_2, \ldots, e_n] \mid e_1 \varepsilon E_1, e_2 \varepsilon E_2, \ldots, e_n \varepsilon E_n\},$$

and each tuple of entities $[e_1, e_2, .., e_n]$ is a relationship.

The role of an entity in a relationship is the function that it performs in the relationship. For example, in relationship, "MARRIAGE", "HUSBAND" and "WIFE" are roles. (See Figure 2).

* Attributes, Value, and Value Set. The information about an entity or a relationship is obtained by observation and is expressed by a set of attribute values.

Values are classified into different value sets, a value in a value set may be equivalent to another value in a different value set. For example, "12" in value set INCH is equivalent to "1" in value set FEET.

An attribute is defined as a function which maps from an entity set or a relationship set into a value set or a Cartesian product of value sets:

$$f: E_i \text{ or } R_i \longrightarrow V_i \text{ or } V_{i1} \times V_{i2} \times V_{i3} \times \ldots \times V_{in}.$$

where E_i = Entity set, R_i = Relationship set

and V_i = Value set.

Therefore, it maps a given entity to a single value or a single tuple of values in case of a Cartesian product of value sets.

Note that relationships also have attributes. Consider the relationship set, PROJECT-WORKER which consists of two entities, PROJECT and EMPLOYEE and one attribute PERCENTAGE-OF-TIME, that is the portion of time a particular employee is committed to a particular project. PERCENTAGE-OF-TIME is neither an attribute of EMPLOYEE nor an attribute of PROJECT, since its meaning depends on both the EMPLOYEE and PROJECT involved. /Functional Dependency in Codd 3/

The concept of attribute of relationship is important in understanding the semantics of data and in determining the functional dependencies among data.

3. CONCEPTUAL INFORMATION STRUCTURE (LEVEL 1)

The conceptual information structure is concerned with how to organize the information associated with entities and relationships. The method is to separate the information about entities from the information about relationships. This separation should be done with regard to identifying functional dependencies among data. [Codd 3, Martin 6, and Fagin 4].

Figure 2 illustrates in table form the information about entities in an entity set, EMPLOYEE. Figure 3 shows information about relationships in a relationship set, WORKER-PROJECT. Note that each row of values is related to a relationship which is indicated by a group of entities, each having a specific role and belonging to a specific entity set. The table form is used for ease in relating to the Relational Model.

4. INFORMATION STRUCTURE (LEVEL 2)

The entities, relationships, and values at level 1 are conceptual objects.

At level 2, the representation of conceptual objects should be considered.

a. Primary Key

In Figure 2, the values of attribute (V_1) EMPLOYEE-NO can be used to identify entities in entity set EMPLOYEE if each employee has a unique employee number.

Not every entity and relationship will have a single-attribute primary key. However, some entities and relationships (relation in Relational Model) will have some combination of attributes that, when taken together, have the unique identification property.

ATTRIBUTE VALUE SET	(EMPLOYEE-NO)	(NAME)		(ALTERNATE NAME)		AGE
E_i (EMPLOYEE)	V_1 (EMPLOYEE-NO)	V_2 (FIRST-NAME)	V_3 (LAST-NAME)	V_2 (FIRST-NAME)	V_3 (LAST-NAME	V_4 NO-OF YEARS)
e_1	1266	PETER	JONES	SAM	JONES	25
:	:	:	:	:	:	:

Figure 2. Information About Entities.

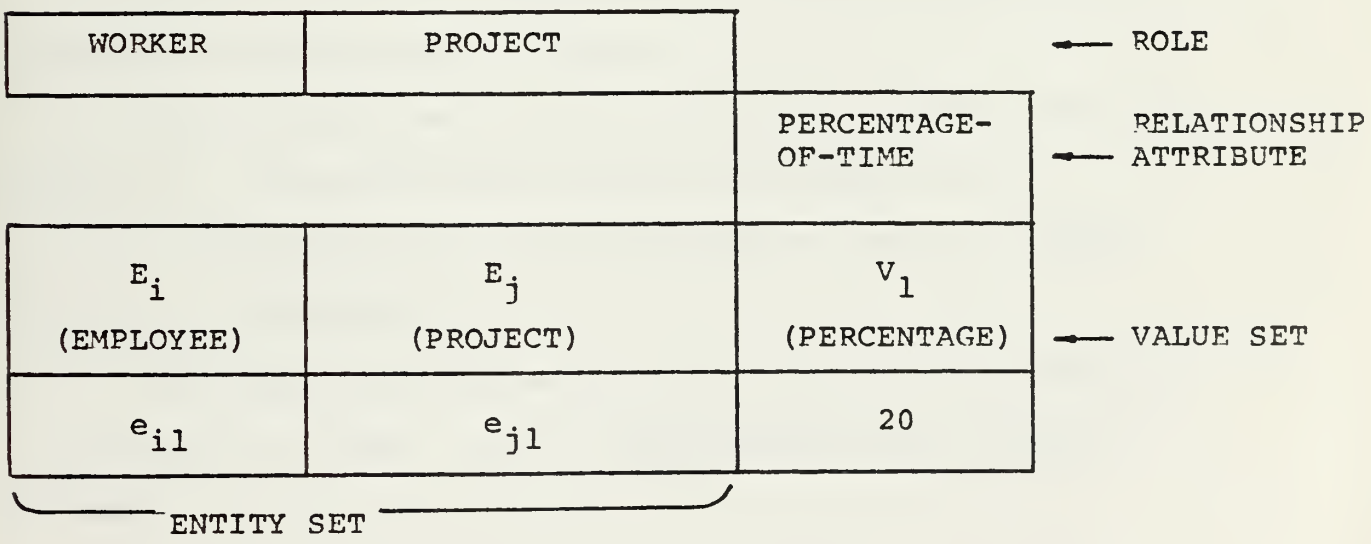


Figure 3. Information About Relationships.

In the case where several keys exist, a semantically meaningful key will be chosen as the entity primary key (PK).

Since a relationship is identified by the involved entities, the primary key of a relationship can be represented by the primary key of the entities involved. /Foreign key, Date 57.

5. SYSTEM ANALYSIS USING THE ENTITY-RELATIONSHIP DIAGRAM

The entity-relationship diagram introduces a diagrammatic technique for exhibiting entities and relationships. Figure 4 illustrates the entity sets and the relationship sets involved in designing a data base. Each entity set is represented by a rectangular box and each relationship set by a diamond-shaped symbol. For example, the relationship set PROJECT-WORKER is defined on the entity sets, EMPLOYEE and PROJECT. This connectivity is represented by the lines connecting the rectangular boxes and by M:N/1:N mapping.

Several important characteristics about relationships in general can be found in Figure 4.

* A relationship set may be defined on more than two entity sets (i.e., SUPPLIER-PROJECT-PART relationship set).
* A relationship set may be defined on only one entity set. (i.e., COMPONENT).
* There may be more than one relationship set defined on given entity sets. (i.e., PROJECT-WORKER and PROJECT-MANAGER).

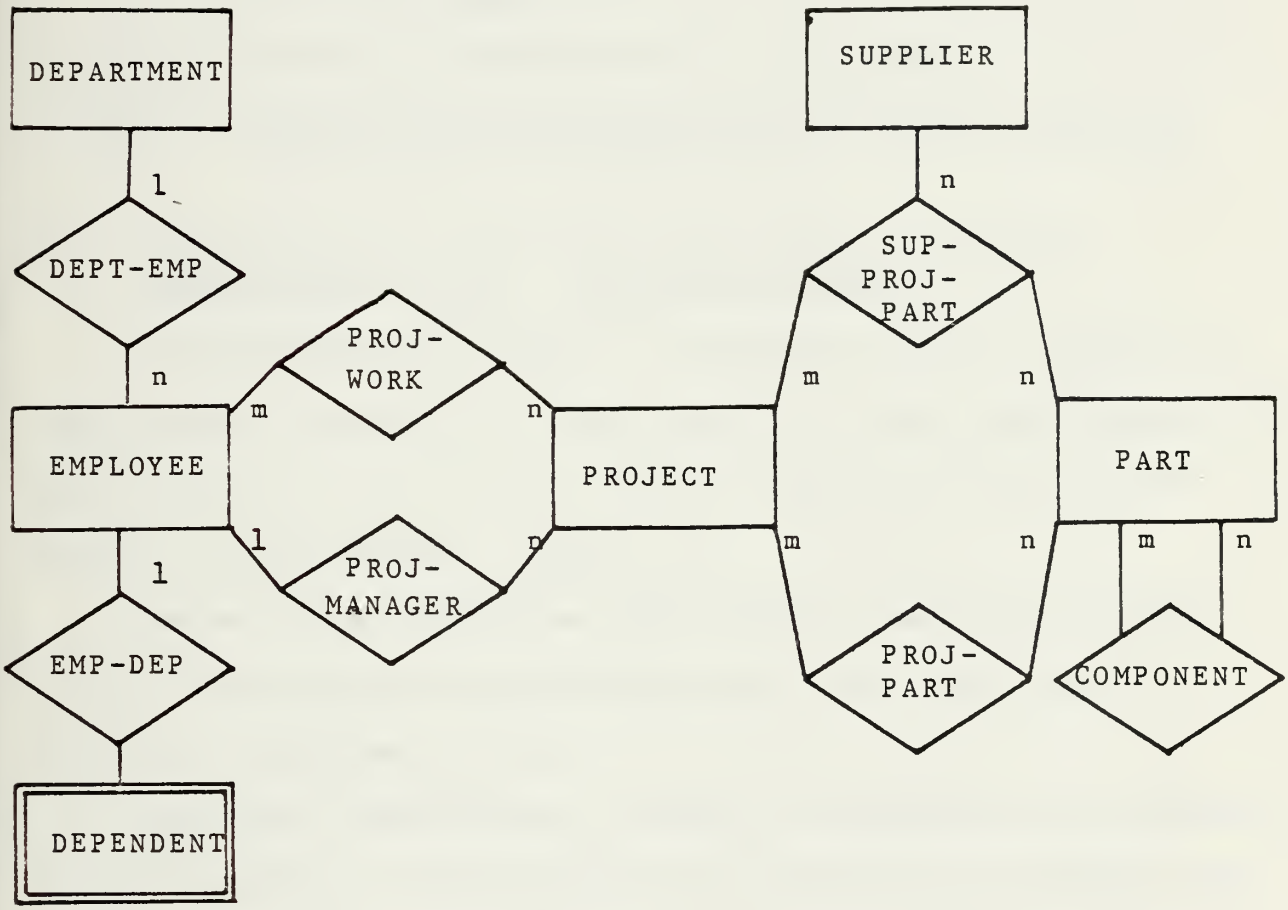


FIG 4: An Entity-Relationship Diagram for analysis of information in a manufacturing firm.

6. DATA BASE DESIGN

Four steps in designing a data base using the entity-relationship model were presented.

Step 1: Identify the entity sets and the relationship sets of interest.

Step 2: Identify semantic information in the relationship sets such as whether a certain relationship set is an 1:N mapping.

Step 3: Define the value sets and attributes.

Step 4: Organize data into entity/relationship relations and identify the primary key.

7. DERIVATION OF OTHER DATA MODELS FROM THE ENTITY-RELATIONSHIP MODEL. (RELATIONAL MODEL)

In the relational model, "attribute" B of a relation is functionally dependent on "attribute" A of the same relation if each value of A has no more than one value of B associated with it in the relation /Codd 3_7.

Semantics of functional dependencies among data become clear in the entity-relationship model. Two major types of functional dependencies are:

-- Functional dependencies related to description of entities or relationship. The non-key value sets will functionally depend on any key value set either in an entity or in relationship.

-- Functional dependencies related to entities in a relationship. Let us assume that PROJECT-NO is the primary key in the entity relation PROJECT and in the relationship relation PROJECT-MANAGER. The value set EMPLOYEE-NO will be functionally dependent on the value set PROJECT-NO if each project has only one manager (1:1 mapping).

From the definition of a "relation", any grouping of domains can be considered to be a relation.

To avoid three types of anomalies (insertion, deletion, update in /Codd 3/), a normalization process is proposed to transform arbitrary relations into the first normal form, then into the second, and finally into the third normal form (3NF). If necessary, as described in /Fagin 4/, a further transformation into a new normal form should be carried out. For example, let us use a simplified version of the normalization process described in /Martin 6/.

Sp (Supplier #, part #, supplier-name, supplier-details price)

Certain rules are applied to transform the above relation into the third normal form

Supplier (Supplier #, Supplier-name, Supplier-details).

part (part #, part-details).

Sp (Supplier #, part #, price).

Using the entity-relationship diagram in Figure 3, the three relations can be easily derived.

Note that in the example above, entity/relationship relations are similar to the 3NF relations in the relational model.

The decomposition process (transformation) for normalization of an arbitrary relation can be viewed as a "bottom-up approach". The entity-relationship model adopts a "top-down approach" using semantically clearer information to organize data in entity/relationship relations.

APPENDIX B

DESCRIPTION OF ENTITIES AND RELATIONSHIPS

ENTITY LINE ITEM (NSN):

Identified by: NSN-NO;
Consist of: NOMEN (Nomenclature);
UNIT-ISSUE;
UNIT-PRICE;
RICC (Reportable Item Control Code);

Cardinality: Number of line items determined by the selection criteria.

ENTITY UNIT:

Identified by: UIC (Unit Identification Code);
Consist of: FAD (Force Activity Designator);
MAJ-COMD (Major Command);

Cardinality: Determined by level of command in logistics operation view of DOA Hqs.

ENTITY AUTHORIZATION (AUTHORIZATION DOCUMENT):

Identified by: AUTH-DOC;
Consist of: DATE-E (Effective Date);

Cardinality: Number of authorization documentation covering all basic units in data base.

ENTITY ARMY WIDE DEPOT:

Identified by: DEPOT-ID;
Consist of: SERVICE (Service Supporting);

Cardinality: Number of depots supporting army logistics operation.

ENTITY INTERMEDIATE ECHELON (GS ACTIVITY):

Identified by: GS-ID;
Consist of: MAJ-COMD;

Cardinality: Number of intermediate echelon.

ENTITY CONTRACTOR REPAIR:

Identified by: CONTRACTOR-ID;
Consist of: Location;
Address;

Cardinality: Number of contractor involved in army contract repair program.

ENTITY SUPPLIER:

Identified by: SUP-ID;
Consist of: Country;
Location;
Address (Correspondence);

Cardinality: Number of supplier from in/out country involved in army material acquisition program.

ENTITY PROJECT (UTILIZATION, ACQUISITION):

Identified by: PROJECT ID;
Consist of: PROJECT-DES (Description);
DATE-E
DATE-C
DEPT-PROJ

Cardinality: Number of projects.

ENTITY LINE ITEM NUMBER (LIN):

Identified by: LIN-NO;
*Consist of: NONE;

Cardinality: Number of line item number determined by selection criteria.

RELATIONSHIP AUTH; (MTOE/TDA):

Synonyms are: Authorization;
Between: LIN and Authorization Document
Connectivity is: One authorization document contains many line items and one line item number (LIN) is related to several authorization document;

Cardinality: Sum of LIN's per authorization document

Attributes are: QTY-REQ;
QTY-AUTH.

RELATIONSHIP SERVICE-CHANNEL:

Synonyms are: None;
Between: Unit and GS level;
Connectivity is: One unit belongs to one GS level activity;

Cardinality: Sum of units;

*Attributes: None.

RELATIONSHIP UNIT-AUTH-ASSOC:

Synonyms are: None;
Between: Unit and Authorization Documentation;
Connectivity is: One unit belongs to one Authorization Documentation;

Cardinality: Sum of units;

*Attributes: None.

RELATIONSHIP LIN-NSN-ASSOC.:

Synonyms are: Association between LIN and NSN;
Between: LIN and NSN;
Connectivity is: One LIN has one or more NSN's;

Cardinality: Sum of NSN's per LIN;

Attributes: None.

RELATIONSHIP UNIT-ON-HAND:

Synonyms are: None;
Between: UNIT and NSN;
Connectivity is: One unit has one or more NSN's per LIN authorized;

One LIN is related to many units;

Cardinality: Sum of NSN's per LIN on-hand in each unit;

Attributes: QTY-OH.

RELATIONSHIP STOCK LEVEL-DEPOT/STOCK-LEVEL-GS

(Separate Stock Level For Army Wide Depot And GS Level)

Synonyms are: Stock-operational;
Between: DEPOT/GS and NSN;
Connectivity is: One depot has many line items in stock (operational) and one line item is only related to a specific depot.

In case of GS level, one GS has many line items and one line item can be kept in many GS levels;

Cardinality: Sum of NSN's per depot;
Sum of NSN's per GS;

Attributes: OPN-STOCK;
SAFETY-STOCK;
REPL-STOCK.

RELATIONSHIP MAINTENANCE FLOAT (MF):

(Separate Maintenance Float For Operational Readiness Float (ORF) In GS Level And Repair Cycle Float (RCF) In Army Wide Depot)

Synonyms are: ORF-MF/RCF-MF;
Between: Army Wide Depot and NSN;
GS Level and NSN;
Connectivity: One army wide depot has many MF(RCF) and one MF(RCF) item belongs to one depot;

One GS level has many MF(ORF) and one MF(ORF) item belongs to many GS levels;

Cardinality: Sum of MF(RCF) per depot;
Sum of MF(ORF) per GS level;

Attributes: QTY-REQ;
QTY-OH.

RELATIONSHIP: WAR RESERVE:

Synonyms are: None;
Between: Army wide depot and NSN:
Connectivity is: One army wide depot holds many line items (NSN) as war reserve;

Cardinality: Sum of line items per depot which holds war reserve;

Attributes: QTY-REQ;
QTY-OH;
DATE-RESVD (DATE RESERVED).

RELATIONSHIP OPN-PROJ-STOCK:

Synonyms are: Operational project stock;
Between: Project and line item (NSN);
Connectivity is: One army wide depot holds many line items (NSN) as war reserve;

Cardinality: Sum of line items per depot which holds operational project stock;

Attributes: QTY-REQ;
QTY-OH;
DATE-RESVD (Date Reserved).

RELATIONSHIP: PROJ-ITEM;

Synonyms are: Project-item (Utilization)
Between: Line item and project (utilization);
Connectivity is: One project (utilization) has many line items (NSN) and one line item may belong to many projects;

Cardinality: Sum of NSN's per project;

Attributes: QTY-REQ;
QTY-COMT (Quantity-Committed).

RELATIONSHIP CONTRACTOR-ACT (DEPOT-CONTRACTOR-NSN-ASSOC.):

Synonyms are: Contractor-Activity;
Between: Contractor and NSN;
Connectivity is: One contractor belongs to many line items which belong to one or more depot activity;

Cardinality: Sum of line items per contractors;

Attributes: QTY-SHIP;
FUND-CODE;
QTY-REPAIR;
DATE-DUE-IN.

RELATIONSHIPS SUP-PROJ-ITEM:

Synonyms are: Supplier-project-item (acquisition)
Between: NSN, project (acquisition) and supplier;
Connectivity is: One project has many line items, but one line item may belong to a specific project (acquisition). Supplier can provide many kinds of line items. This means a supplier can support many projects.

Cardinality: Sum of NSN's per project;

Attributes: PRICE-PURCH;
TOTAL-QTY-DEL-SCH;
TOTAL-QTY-DEL-ARR;
DATE-DEL-SCH;
DATE-DEL-ARR;
QTY-DEL-SCH;
QTY-DEL-ARR.

APPENDIX C

EVALUATION OF LOGICAL DESIGN

A relational system organizes the data, in a data base, according to the relational data model. In addition, it provides a relational data language for accessing a relational data base.

The relational data language provides facilities capable of emulating the relational operators which allow a user to construct new relations from existing relations.

In a relational system, several different kinds of relations can be distinguished. Some relations are independent; they are defined initially (schema in /Date 57). Such relations will be called primary relations. In contrast, relations defined using relational operators on primary relations will be called "derived relations" (subschema in /Date 57). For example, the JOIN of two primary relations is a derived relation.

External model (combination of primary and derived relation) is an individual user's view of the data base. (definition of alternative "VIEWS" which are derived from the stored data in /Chamberlin 15, Tsichritzis 107).

It may be thought of as a restriction of the conceptual model -- which is the total community user views -- to just that portion which is of interest to that particular user.

The definition of external model (VIEW) is simply a process of deriving a relation from the set of stored relations and that is similar to the process of stating a query.

A view may be a selected subset of a stored relation, or it may extend over more than one stored relation, as in the case of a "JOIN" operation. Once the definition of a view has been made, queries can be directed to the external model.

Evaluation of the logical design will be accomplished by using a relational data base management system in terms of derivability of the external model from the stored relations.

The application programs are the following, as stated previously in Chapter 3. (See Data Usage Matrix: III.B).

1 Army equipment status reporting.

2 Stockage status.

3 Maintenance float status.

4 War reserve.

5 Operational project stock.

6 Material utilization (acquisition) status.

7 Contractor repair status.

8 End item information for distribution query.

The data manipulation language utilized in evaluating the logical relation data base is QUEL supported by the INGRES system, currently available at the Naval Postgraduate School (See INGRES Manual).

1. Army Equipment Status Reporting

-- Process: AESR

-- Description: Generate reports by each unit on the authorized and on-hand quantities of the selected end items.

-- Frequency: Monthly if necessary.
And daily query.

-- Relations And Attributes Involved:

Relation	Attributes
UNIT	UIC; AUTH-DOC;
AUTH	AUTH-DOC; * LIN-NO; * QTY-AUTH; * QTY REQ;
LINE-ITEM	LIN-NO; NSN-NO; * NOMEN; * UNIT-ISSUE;
UNIT-ON-HAND	NSN-NO; NIC; * QTY-OH;

-- Query Specification

```
/*  SELECT UNIT WHERE  UIC = "UIC_i" GIVING TEMP1.
/*  PROJECT TEMP1 OVER AUTH-DOC GIVING TEMP2.
/*  SELECT AUTH WHERE AUTH-DOC = TEMP2 GIVING R1.
    READ (UIC_i)
    RANGE OF X IS UNIT
    RANGE OF Y IS AUTH
    RETRIEVE INTO R1 Y.LIN-NO, Y.QTY-REQ, Y.QTY-AUTH)
    WHERE  X.AUTH-DOC = Y.AUTH-DOC AND X.UIC = "UIC_i"
/*  SELECT UNIT-ON-HAND WHERE UIC = "UIC_i" GIVING TEMP1.
/*  JOIN TEMP1 AND LINE-ITEM OVER NSN-NO GIVING TEMP2.
/*  PROJECT TEMP 2 OVER NSN-NO, LIN-NO, NOMEN, UNIT-ISSUE,
/*                      QTY-OH GIVING R2.
    RANGE OF Z IS UNIT-ON-HAND
    RANGE OF S IS LINE-ITEM
    RETRIEVE INTO R2 (S.NSN-NO, S.LIN-NO, S.NOMEN,
                      S.UNIT-ISSUE, Z.QTY-OH)
    WHERE  Z.NSN-NO = S.NSN-NO AND X.UIC = "UIC_i"
/*  JOIN R1 AND R2 OVER LIN-NO GIVING TEMP.
    RANGE OF A IS R1
    RANGE OF B IS R2
```

```
RETRIEVE INTO R3 (A.LIN-NO, A.QTY-AUTH,
                  B.NSN-NO, B.NOMEN, B.UNIT-ISSUE,
                  B.QTY-OH)
   WHERE  A.LIN-NO = B.LIN-NO
```

2. Stockage Status

-- Process: STOCK-DEPOT/STOCK-GS:

-- Description: Generate reports by each depot or GS level on the stock level kept in Depot or GS.

-- Frequency: Monthly if necessary
And daily query.

-- Relations And Attributes Involved:

Relation	Attributes
STOCK-LEVEL-DEPOT (STOCK-LEVEL-GS)	NSN-NO; * OPN-STOCK; * SAFETY-STOCK; * REPL-STOCK; DEPOT-ID (GS-ID);
LIN-ITEM	* LIN-NO; * NSN-NO; * NOMEN; * UNIT-ISSUE; * UNIT-PRICE;

-- Query Specification

```
    READ (DEPOT-ID_i)
/*  SELECT STOCK-LEVEL-DEPOT WHERE DEPOT-ID =
/*  "DEPOT-ID_i" GIVING TEMP1.
/*  PROJECT TEMP1 OVER NSN-NO, OPN-STOCK, SAFETY-STOCK,
/*                     REPL-STOCK GIVING TEMP2.
/*  JOIN TEMP2 AND LINE-ITEM OVER NSN-NO
/*  GIVING TEMP3.
/*  PROJECT TEMP3 OVER NSN-NO, LIN-NO,
/*  MOMEN, UNIT-PRICE, OPN-STOCK, SAFETY-STOCK,
/*  REPL-STOCK GIVING R1.
    RANGE OF  X  IS STOCK-LEVEL-DEPOT
    RANGE OF  Y  IS LINE-ITEM
```

```
RETRIEVE INTO R1 (Y.NSN-NO, Y.LIN-NO, Y.NOMEN,
                  Y.UNIT-PRICE, X.OPN-STOCK,
                  X.SAFETY-STOCK, X.REPL-STOCK)
    WHERE  X.NSN-NO = Y.NSN-NO AND X.DEPOT-ID =
           "DEPOT-ID_i"
```

-- Same procedure can be applied to GS Level Stock Status by replacing "DEPOT-ID$_i$" and the relation with corresponding ID and relation: STOCK-LEVEL-GS.

3. Maintenance Float Status

-- Process: MF-RCF-STATUS;

-- Description: Generate reports by each depot on the maintenance-float.(RCF) status.

-- Frequency: Monthly if necessary
And daily query.

-- Relations And Attributes Involved:

Relations	Attributes
MAINT-FLOAT-RCF	DEPOT-ID;
	NSN-NO;
	* QTY-REQ;
	* QTY-OH;
LINE-ITEM	* NSN-NO;
	* LIN-NO;
	* NOMEN;
	* UNIT-ISSUE;

-- Query Specification

```
    READ  (DEPOT-ID_i)
/*  SELECT MAINT-FLOAT-RCF WHERE DEPOT-ID =
/*  "DEPOT-ID_i" GIVING TEMP.
/*  JOIN TEMP AND LINE-ITEM OVER NSN-NO GIVING R1.

    RANGE OF  X  IS MAINT-FLOAT-RCF
    RANGE OF  Y  IS LINE-ITEM

    RETRIEVE INTO R1 (Y.NSN-NO, Y.LIN-NO, Y.NOMEN,
                      Y.UNIT-ISSUE, X.QTY-REQ,
                      X.QTY-OH)
```

WHERE X.NSN-NO = Y.NSN-NO AND X.DEPOT-ID = "DPOT-ID$_i$"

-- Same procedure can be applied to MF-ORF-GS by replacing "DEPOT-ID$_i$" and the relation with corresponding "GS-ID$_i$" and relation: Maint-Float-ORF.

4. War Reserve Status

-- Process: WAR-RESERVE-STATUS.

-- Description: Generate report of war reserve status.

-- Frequency: When necessary
And daily query.

-- Relations And Attributes Involved:

Relations	Attributes
WAR-RESERVE	* DEPOT-ID; NSN-NO; * QTY-REQ; * QTY-OH; * DATE-RESVD:
LINE-ITEM	* NSN-NO; * LINE-NO; * MOMEN; * UNIT-ISSUE; * UNIT-PRICE;

-- Query Specification.

```
/*  JOIN WAR-RESERVE AND LINE ITEM
/*  OVER NSN-NO GIVING R1.
    RANGE OF  X  IS  WAR-RESERVE
    RANGE OF  Y  IS  LINE-ITEM
    RETRIEVE INTO R1 (Y.NSN-NO, Y.LIN-NO, Y.NOMEN,
                      Y.UNIT-ISSUE, Y.UNIT-PRICE,
                      X.DEPOT-ID, X.QTY-REQ, X.QTY-OH,
                      X.DATE-RESVD)

/*  IF REPORTS BY EACH DEPOT ARE NEEDED
/*  SELECT R1 WHERE R1.DEPOT-ID = "DEPOT-ID_i"
/*  GIVING R2.
    RANGE OF Z IS R1
```

```
RETRIEVE (Z.NSN-NO, Z.LIN-NO, Z.NOMEN,
          Z.UNIT-ISSUE, Z.UNIT-PRICE, Z.QTY-REQ,
          Z.DATE-RESVD)
   WHERE  DEPOT-ID = "DEPOT-ID_i"
```

5. Operational Project Stock

-- Process: OPN-PROJ-STOCK-STATUS.

-- Description: Generate reports by project and location (Depot) on operational-project-stock-status.

-- Frequency : When necessary and daily query.

-- Relations And Attributes Involved:

Relation	Attributes
OPN-PROJ-STOCK	* DEPOT-ID; * PROJECT-ID; NSN-NO; * QTY-REQ; * QTY-OH;
LINE-ITEM	* NSN-NO; * LIN-NO; * MOMEN; * UNIT-ISSUE; * UNIT-PRICE;

-- Query Specification

```
/*  JOIN OPN-PROJ-STOCK AND LINE-ITEM
/*  OVER NSN-NO GIVING R1.
    RANGE OF  X  OPN-PROJ-STOCK
    RANGE OF  Y  LINE-ITEM
    RETRIEVE INTO R1 (Y.NSN-NO, Y.LIN-NO, Y.NOMEN,
                      Y.UNIT-ISSUE, Y.UNIT-PRICE,
                      X.DEPOT-ID, X.PROJ-ID,
                      X.QTY-REQ, X.QTY-OH)
/*  IF REPORTS BY PROJECT ARE NEEDED
/*  SELECT R1 WHERE R1. PROJECT-ID = "PROJECT-ID_i"

    RANGE OF  Z  IS R1
```

```
        RETRIEVE INTO R1 (Y.NSN-NO, Y.LIN-NO, Y.NOMEN,
                          Y.UNIT-ISSUE, Y.UNIT-PRICE,
                          X.QTY-REQ, X.QTY-COMT,
                          Z.QTY-COMT, Z.PROJ-ID, Z.DATE-E,
                          Z.DATE-C)
            WHERE X.PROJECT-ID = Z.PROJECT-ID
            AND X.NSN-NO = Y.NSN-NO
    /*  IF REPORTS BY PROJECT ARE NEEDED
    /* SELECT R1 WHERE R1.PROJECT-ID = "PROJECT-ID_i".
       RANGE OF A IS R1
       RETRIEVE (/ATTRIBUTES NECESSARY/) WHERE
                  PROJECT-ID = "PROJECT-ID_i"
```

7. Contractor-Repair Status

-- Process: Contractor-Repair-Status

-- Description: Generate report of Contractor Repair activity.

-- Frequency: Monthly and daily query.

-- Relations And Attributes Involved:

Relation		Attributes
DEPOT-CONTRACTOR-	*	CONTRACTOR-ID;
NSN	*	NSN-NO;
	*	QTY-SHIP;
	*	FUND-CODE;
	*	QTY-REPAIR;
	*	DATE-DUE-IN;
LINE ITEM		NSN-NO;
	*	LIN-NO;
	*	NOMEN;
	*	UNIT-ISSUE;
STOCK-LEVEL-DEPOT		DEPOT-ID;
		NSN-NO;

-- Query Specification

```
    /*  PROJECT STOCK-LEVEL-DEPOT OVER DEPOT-ID AND
    /*  NSN-NO GIVING TEMP.
    /*  JOIN TEMP AND DEPOT-CONTRACTOR-NSN OVER
    /*  NSN-NO GIVING RESULT.
```

```
        RETRIEVE (Z.NSN-NO, Z.LIN-NO, Z.NOMEN,
                  Z.UNIT-ISSUE, Z.UNIT-PRICE, Z.DEPOT-ID,
                  Z.QTY-REQ, Z.QTY-OH)
           WHERE  Z.PROJ-ID = "PROJECT-ID_i"
    /*  IF REPORTS BY LOCATION (DEPOT) ARE NEEDED
    /*  SELECT R1 WHERE R1. DEPOT-ID = "DEPOT-ID_i".

        RANGE OF A IS R1
        RETRIEVE (A.NSN-NO, A.LIN-NO, A.NOMEN, A.UNIT-ISSUE,
                  A.UNIT-PRICE, A.PROJECT-ID, A.QTY-REQ,
                  A.QTY-OH)
```

6. Material Utilization (Acquisition) Status

-- Process: MATERIAL-UTIL-STATUS

-- Description: Generate report by project on quantity-required and on-hand.

-- Frequency: When necessary and daily query.

-- Relations And Attributes Involved:

Relation	Attribute
PROJ-ITEM	PROJECT-ID;
	NSN-NO;
	* QTY-REQ;
	* QTY-COMT;
LINE-ITEM	* NSN-NO;
	* LIN-NO;
	* NOMEN;
	* UNIT-ISSUE;
	* UNIT-PRICE;
PROJECT	* PROJECT-ID;
	* DATE-E;
	* DATE-C;

-- Query Specification

```
    /*  JOIN PROJ-ITEM AND PROJ OVER PROJECT-ID GIVING
    /*  TEMP.
    /*  JOIN TEMP AND LINE-ITEM OVER NSN-NO GIVING R1.
        RANGE OF  X  IS PROJ-ITEM
        RANGE OF  Y  IS LINE-ITEM
        RANGE OF  Z  IS PROJECT
```

```
/*  JOIN RESULT AND LINE-ITEM OVER NSN-NO GIVING R1
    RANGE OF X IS STOCK-LEVEL-DEPOT
    RANGE OF Y IS LINE-ITEM
    RANGE OF Z IS DEPOT-CONTRACTOR-NSN
    RETRIEVE INTO R1 (Z.CONTRACTOR-ID, Z.NSN-NO,
                      Y.LIN-NO, Y.NOMEN, Y.UNIT-ISSUE,
                      Z.QTY-SHIP, X.DEPOT-ID,
                      Z.QTY-REPAIR, Z.DATE-DUE-IN,
                      Z.FUND-CODE)
      WHERE X.NSN-NO =Z.NSN-NO
      AND   Z.NSN-NO = Y.NSN-NO
/*  ANSWER BY QUALIFICATION SATISFIED BY QUERY.
/*                    -- BY CONTRACTOR-ID
/*                    -- BY DATE-DUE-IN
/*                    -- BY FUND-CODE
/*                    -- BY DEPOT WHICH RECEIVE THE
                         ITEM REPAIRED
    RANGE OF X IS R1
    RETRIEVE (/ATTRIBUTES NECESSARY/)
    WHERE QUALIFICATION SATISFIED
```

8. End Item Information For Distribution Query

-- Process: None (Simple Query)

-- Description: Retrieve information about a given end item (location, quantity on-hand and authorized, and quantity available).

-- Frequency: Daily query.

-- Relations And Attributes

Relations	Attributes
AUTH	LIN-NO; AUTH-DOC; QTY-REQ; QTY-AUTH;
UNIT	UIC; FAD; MAJ-COMD; AUTH-DOC;
UNIT-ON-HAND	UIC; NSN-NO; QTY-OH;

```
LINE ITEM              NSN-NO;
                       LIN-NO;
                       NOMEN;
                       UNIT-ISSUE;

DEPOT-STOCK-LEVEL      NSN-NO;
                       DEPOT-ID;
                       STOCK-LEVEL(S)
```

-- Query Specification

```
    READ (LIN-NO_i)
/*  WHO IS AUTHORIZED.
/*  SELECT AUTH WHERE LIN-NO = "LIN-NO_i" GIVING
/*  TEMP.
/*  JOIN TEMP AND UNIT OVER AUTH-DOC GIVING R1.
/*  PROJECT R1 OVER UIC GIVING TEMP.
    RANGE OF X IS AUTH
    RANGE OF Y IS UNIT
    RETRIEVE INTO R1 (X.LIN-NO, X.AUTH-DOC,
                      X.QTY-REQ, X.QTY-AUTH, Y.UIC,
                      Y.FAD, Y.MAJ-COMD, Y.AUTH-DOC)
      WHERE Y.AUTH-DOC = X.AUTH-DOC
      AND X.LIN-NO = "LIN-NO_i"
    RANGE OF Z IS R1
    RETRIEVE (Z.UIC, Z FAD, Z.MAJ-COMD)
/*  ANSWER BY FAD, AND MAJOR COMMAND
/*  CAN BE ACCOMPLISHED BY USE OF R1.
/*  HOW MANY ON-HAND.
/*  SELECT LINE ITEM WHERE LIN-NO = "LIN-NO_i"
/*  GIVING TEMP.
/*  PROJECT TEMP OVER LIN-NO, NSN-NO, GIVING
/*  TEMP2.
/*  JOIN TEMP 2 AND UNIT-ON-HAND OVER NSN-NO
/*  GIVING R2.
    RANGE OF X IS LINE-ITEM
    RANGE OF Y IS UNIT-ON-HAND
    RETRIEVE INTO R2 (Y.UIC, Y.NSN-NO, X.LIN-NO,
                      Y.QTY-OH)
```

```
      WHERE Y.NSN-NO = X.NSN-NO
      AND X.LIN-NO = "LIN-NO_i"
/*  HOW MANY AUTHORIZED AND ON-HAND.
/*  JOIN R1 AND R2 OVER UIC AND LIN-NO
/*  GIVING R3.
    RANGE OF X IS R1
    RANGE OF Y IS R2
    RETRIEVE INTO R3 (X..AUTH-DOC, X.UIC, X.QTY-REQ,
                      X.QTY-AUTH, Y.NSN-NO,
                      Y.QTY-OH, X.FAD, X.MAJ-COMD)
      WHERE X.UIC = Y.UIC
      AND  X.LIN-NO = Y.LIN-NO
/*  ANSWER BY FAD, MAJ-COMD CAN BE ACCOMPLISHED
/*  BY USE OF R3.
/*  TO KNOW THE AVAILABILITY OF A GIVEN END-ITEM
/.  FROM DEPOT STOCK
/*  SELECT LINE ITEM WHERE LIN-NO = "LIN-NO_i"
/*  GIVING TEMP.
/*  JOIN TEMP AND DEPOT-STOCK-LEVEL-OVER
/*  NSN-NO GIVING R4.
    RANGE OF X IS LINE-ITEM
    RANGE OF Y IS DEPOT-STOCK-LEVEL
    RETRIEVE INTO R4 (X.NSN-NO, X.NOMEN, Y.STOCK-
                      LEVEL(S))
    WHERE X.LIN-NO = "LIN-NO_i"
    AND X.NSN-NO = Y.NSN-NO
```

APPENDIX D

SAMPLE QUERIES OF INGRES

For the purpose of this discussion, it is assumed that the reader is familiar with INGRES and understands QUEL, the INGRES query language.

To create a new data base, the user must be a valid INGRES user and have "CREATE DATA BASE" permission. We can create a data base using the command to the UNIX Shell: % create logistics, where "logistics" is the name of the data base. When we wish to destroy the data base, we type % destroy db logistics.

There are two ways to create new relations in INGRES. These are:

- CREATE
- RETRIEVE INTO

"RETRIEVE INTO" is used to form a new relation from one or more existing relations. "CREATE" is used to create a new relation with no tuples in it.

Example

Create donation (name = C10, amount = f4, ext = i2).

INGRES creates a new relation called "donation" and the name and format for each domain is given.

Once a relation is created, there are two mechanisms for inserting new data:

APPEND Command.

COPY Command.

"APPEND" is used to insert tuples one at a time, or for filling one relation from other relations. "COPY" is used for copying data from a UNIX file into a relation.

We see what relations are in the data base by typing:

* help g

We now examine the "AUTH" relation. We use the "HELP" command to learn about a specific relation. For example:

* help auth.

To examine all domains, we can use the "PRINT" command or "RETRIEVE" command.

We can retrieve results directly onto the terminal. We can also save results by retrieving them into a new relation. This is done by commanding:

* retrieve into new relation (. . . .)

* where qualification specified.

There are two features of "RETRIEVE INTO". First, the result relation is automatically sorted and any duplications are removed. Second, the relation becomes part of the data base and is owned by the creator. If we don't want to save it, we use the * destroy relation name command.

INGRES supports the following aggregates:

```
Count   /*  Count the number of tuples
Min     /*  Minimum value of a given column
Max     /*  Maximum value of a given column
Avg     /*  Average value of a given column
Sum     /*  Sum value of a given column
```

In the following queries, the aggregate utilities were not used. We showed how to generate the derived relations

(i.e., r1 and r2) which will be manipulated in the next steps to generate a final output, including the derived information.

We will also show the derived relations concerned with AUTH, UNIT, UNIT-ON-HAND, and LINE-ITEM relations. By applying the same concept to the rest of the data base, it is possible to generate a relation that can satisfy a specified requirement.

The following pages show:

(1) Relations in the data base.

(2) Structural information about a given relation.

(3) Stored information about a given relation.

(4) Sequence of queries for generating army equipment status reports.

(5) Sequence of queries for generating a derived relation containing relative values with a given line-item-number.

(1). Relations in the Data Base.

```
* help
* \g
Executing . . .

 relation name        relation owner

 relation             yoon
 attribute            yoon
 indexes              yoon
 integrity            yoon
 constraint           yoon
 authte               yoon
 auth                 yoon
 unitte               yoon
 unit                 yoon
 lineitemte           yoon
 lineitem             yoon
 unitonhandte         yoon
 unitonhand           yoon


continue
*
```

(2). Structural informations about a given relation.

```
* help unit
* \g
Executing . . .


Relation:  unit
Owner:     yoon
Tupie width:  21
Saved until:  Wed Jan 30 00:00:00 1980
Number of tuples: 2
Storage structure: ISAM file
Relation type:  user relation

 attribute name      type   length   keyno.

 uic                  i        2        1
 name                 c        7
 fad                  i        1
 majcomd              i        1
 serch                i        1
 authdoc              c        9


continue
*
```

```
* help lineitem
** \g
Executing . . .


Relation:  lineitem
Owner:     yoon
Tuple width:  55
Saved until:  Wed Jan 30 00:00:00 1980
Number of tuples: 10
Storage structure: ISAM file
Relation type:  user relation

 attribute name      type   length   keyno.

 nenno               c        13       1
 lineno              c         6
 nomen               c        25
 ui                  c         2
 up                  f         8
 ricc                i         1


continue
*
```

```
* help auth
* \g
Executing . . .


Relation:  auth
Owner:     yoon
Tuple width:  23
Saved until:  Wed Jan 30 00:00:00 1980
Number of tuples: 11
Storage structure: ISAM file
Relation type:  user relation

 attribute name      type   length   keyno.

 authdoc              c        9        1
 lineno               c        6
 qtyreq               i        4
 qtyauth              i        4


continue
*
```

```
* help unitonhand
* \g
Executing . . .


Relation:  unitonhand
Owner:     yoon
Tuple width:   19
Saved until:   Wed Jan 30 00:00:00 1980
Number of tuples: 13
Storage structure: ISAM file
Relation type:  user relation

 attribute name      type   length   keyno.

 uic                  i        2        1
 nsmno                c       13
 qtyoh                i        4


continue
*
```

(3). Stored informations about a given relation.

```
* print unit
* \g
Executing . . .
```

unit relation

uic	name	fad	majcom	serch	authdoc
1	1ST DIV	0	1	11	MTOE17H
2	2ND DIV	1	2	22	MTOE7H

```
continue
* print lineitem
* \g
Executing . . .
```

lineitem relation

nsnno	lineno	nomen	ui	up	ricc
1015-322-9728	K57392	HOW LT TWD M101	EA	17329.000	1
1025-322-9755	K57803	HOW M114 W/M1A1 CGE	EA	26946.000	1
1025-322-9768	K57803	HOW M114A1 W/M1A2 CGE	EA	30618.000	1
1520-999-9821	K29660	HCPTR ATTACK AH-1G	EA	509833.000	1
2350-678-5773	V13101	TANK CMBT 105MM M60	EA	147500.000	1
2350-739-3841	K56981	HOW HV SP FT 8IN M55	EA	171797.000	1
2350-756-8457	V13101	TANK CMBT 105MM M60A1	EA	264500.000	1
2350-999-4392	J96694	GUN AIR DEF AR SP M163	EA	276377.000	1
5820-223-7540	Q32756	RDO ST AN/GRC-106A	EA	14875.000	1
5820-402-2263	Q32756	RDO ST AN/GRC-106	EA	14875.000	1

```
* print auth
* \g
Executing . . .
```

auth relation

authdoc	lineno	qtyreq	qtyauth
MTOE17H	J96694	24	24
MTOE17H	K29660	9	9
MTOE17H	K56981	12	12
MTOE17H	Q32756	20	20
MTOE17H	V13101	324	320
MTOE7H	J96694	24	24
MTOE7H	K29660	33	33
MTOE7H	K57392	54	50
MTOE7H	K57803	18	18
MTOE7H	Q32756	17	17
MTOE7H	V13101	54	54

```
continue
*
```

```
* print unitcmmd
**\g
Executing . . .

unitcmmd relation

| uic | name | qtyon |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 2 | 2 |
| 1 | 3 | 3 |
| 1 | 4 | 4 |
| 1 | 5 | 5 |
| 1 | 6 | 6 |
| 1 | 7 | 7 |
| 1 | 8 | 8 |
| 1 | 9 | 9 |
| 1 | 10 | 10 |

continue
**
```

(4). Sequence of queries for generating Army Equipment Status Report.

```
* \r
go
** range of x is unit
** retrieve (x.all)
** where x.uic=1
** \g
Executing . . .
```

uic	name	fad	majcom	serch	authdoc
1	1ST DIV	0	1	11	NTOE17H

```
continue
* range of y is auth
* retrieve into r1 (y.lineno,y.qtyreq,y.qtyauth)
** where y.authdoc="NTOE17H"
** \g
Executing . . .


continue
```

```
*
continue
* range of p is r1
* retrieve (p.all)
* \g
Executing . . .

|lineno|qtyreq          |qtyauth           |
|-----------------------------------------|
|J96694|             24|                24|
|K29668|              9|                 9|
|K56981|             12|                12|
|Q32756|             28|                28|
|U13101|            324|               320|
|-----------------------------------------|

continue
*
```

```
* \r
go
* range of z is unitonhand
* range of s is lineitem
* retrieve into r2 (z.nsnno,z.qtyoh,s.lineno,s.nomen)
* where z.nsnno=s.nsnno and z.uic=1
* \g
Executing . . .


continue
* print r2
* \g
Executing . . .
```


r2 relation

nsnno	qtyoh	lineno	nomen
1520-999-9821	7	K29660	HCPTR ATTACK AH-1G
2350-739-3841	10	K56981	HOW HV SP FT 8IN M55
2350-756-8497	300	V13101	TANK CMBT 105MM M60A1
2350-999-4392	23	J96694	GUN AIR DEF AR SP M163
5820-223-7548	10	Q32756	RDO ST AN/GRC-106A
5820-402-2263	0	Q32756	RDO ST AN/GRC-106

```
continue
*
```

```
* \r
go
* range of a is r1
* range of b is r2
* retrieve (a.lineno,a.qtyreq,a.qtyauth,
*           b.nsnno,b.qtyoh,b.nomen)
* where a.lineno=b.lineno
* \g
Executing . . .
```

lineno	qtyreq	qtyauth	nsnno	qtyoh	nomen
J36694	24	24	2350-999-4392	23	GUN AIR DE F A2 SP M163
K29660	9	9	1520-999-9821	7	HCPTR ATTA CK AH-1G
K59981	12	12	2350-739-3841	10	HOW MU SP FT 8IN M55
Q327556	20	20	5820-223-7548	10	RDO ST AN/ GRC-106A
Q327556	20	20	5820-402-2263	8	RDO ST AN/ GRC-106
V13101	324	320	2350-756-8497	300	TANK CMBT 105MM M60A1

```
continue
*
```

(5). Sequence of queries for generating a derived relation containing relative values with a given line item number.

```
* range of x is auth
* retrieve (x.all)
* where x.lineno="Q32756"
* \g
Executing . . .
```

authdoc	lineno	qtyreq	qtyauth
MTOE17H	Q32756	20	20
MTOE7H	Q32756	17	17

```
continue
*
```

```
* range of x is auth
* range of y is unit
* retrieve into r4 (y.uic,y.fad,y.majcomd,x.lineno,
*                   x.qtyreq,x.qtyauth)
* where y.authdoc=x.authdoc and x.lineno="032756"
* \g
Executing . . .


continue
* print r4
* \g
Executing . . .
```

r4 relation

uic	fad	majcom	lineno	qtyreq	qtyauth
1	0	1	032756	20	20
2	1	2	032756	17	17

```
continue
*
```

```
* range of x is lineitem
* range of y is unitonhand
* retrieve into r5 (y.uic,y.nsnno,y.qtyoh,x.lineno)
* where x.nsnno=y.nsnno and x.lineno="Q32756"
* \g
Executing . . .


continue
* print r5
* \g
Executing . . .
```


r5 relation

uic	nsnno	qtyoh	lineno
1	5820-223-7548	10	Q32756
1	5820-402-2263	8	Q32756
2	5820-402-2263	15	Q32756

```
continue
*
```

```
* range of x is r4
* range of y is r5
* retrieve (x.uic,x.fad,x.majcomd,x.lineno,x.qtyreq,x.qtyauth,
*           y.nsnno,y.qtyon)
* where x.uic=y.uic
* \g
Executing . . .

|uic    |fad    |majcom|lineno|qtyreq       |qtyauth      |nsnno          |qty
on        |
|-----------------------------------------------------------------------------
----------|
|     1|      0|     1|032756|           20|           20|5820-223-7548|
       10|
|     1|      0|     1|032756|           20|           20|5820-402-2263|
        8|
|     2|      1|     2|032756|           17|           17|5820-402-2263|
       15|
|-----------------------------------------------------------------------------
----------|

continue
*
```

```
* range of x is r4
* range of y is r5
* retrieve (x.uic,x.lineno,x.qtyreq,x.qtyauth,
*            y.nsnno,y.qtyoh)
* where x.uic=y.uic
* \g
Executing . . .
```

uic	lineno	qtyreq	qtyauth	nsnno	qtyoh
1	032756	20	20	5820-223-7548	10
1	032756	20	20	5820-402-2263	8
2	032756	17	17	5820-402-2263	15

```
continue
*
```

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c.1 Relational data model for management of select-ed items in the Army logistics operation.